Mattrix Technologies

Revolutionary pixels for tomorrow's OLED displays

Intro Deck

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LCD TV Factory
$6B USD (2008)

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SHUTDOWN 2021

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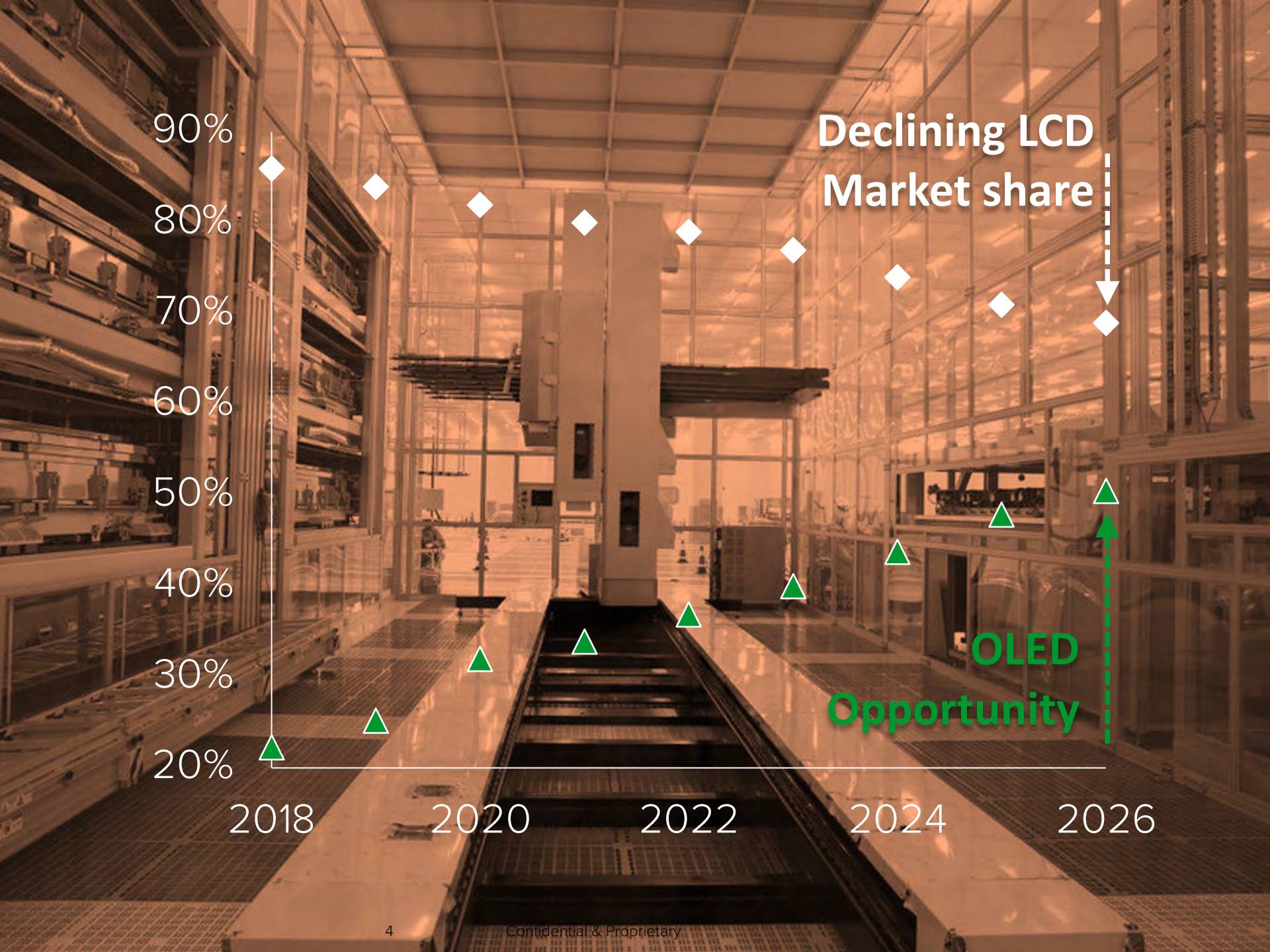

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~~LCD~~ **OLED** TV Factory

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We recycle aging LCD display factories and simplify manufacturing for more ***profitable*** OLED production

Up to $900M in CAPEX savings per factory

>25% reduction in panel manufacturing costs

The “OLED Backplane Problem”

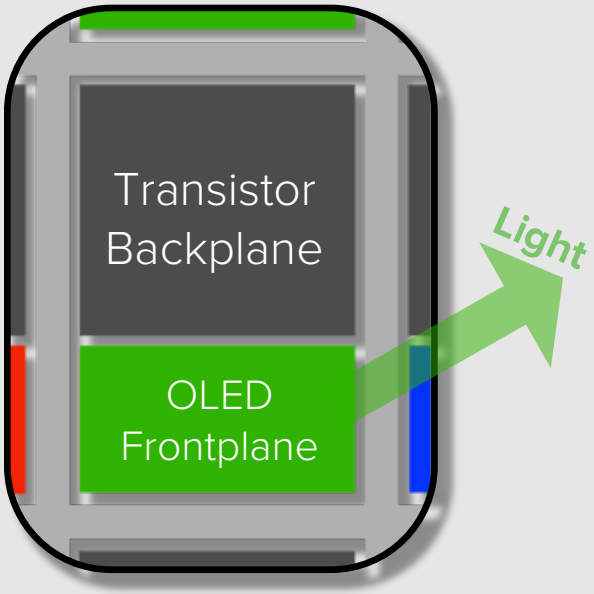
Conventional OLED Pixel

Transistor (TFT) Backplane:

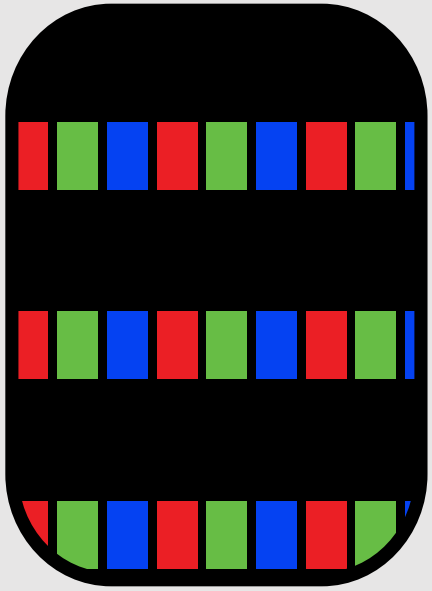
- Supplies current to pixel and acts as the pixel’s internal “*dimmer switch*”

Light-emitting Frontplane:

- converts electrical current to light



Single Pixel Top View



Zoom-in of a TV display (array of OLED pixels)

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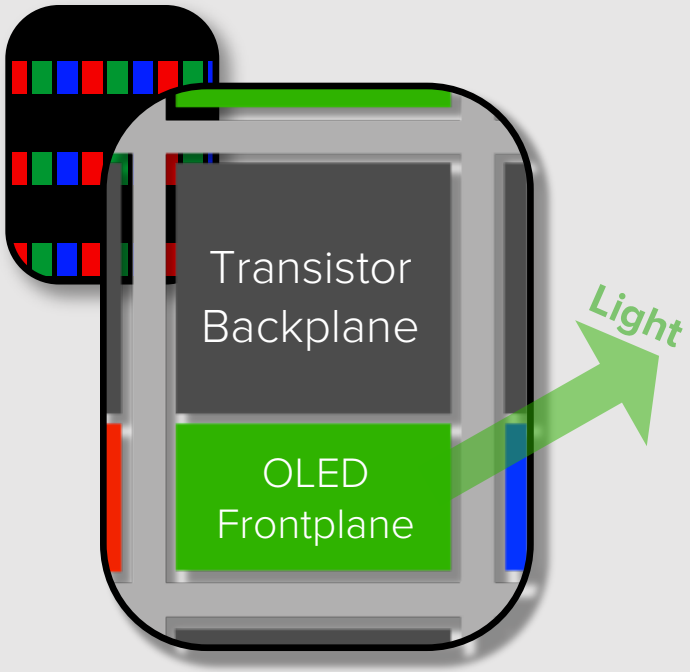
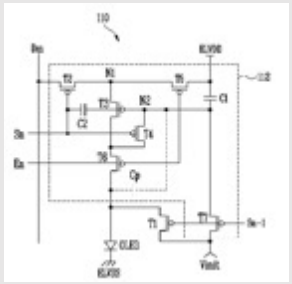
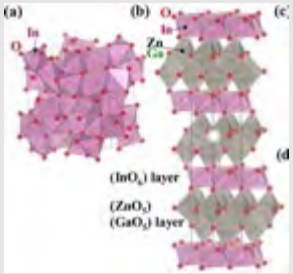


BACKPLANE PROBLEM

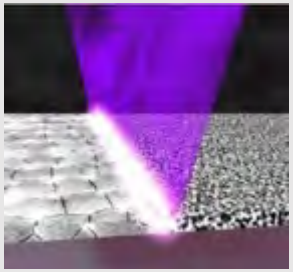
Complex pixel circuits
In-pixel compensation
5 to 7 TFTs



Exotic Materials
Quaternary alloy
Narrow processing window
Light sensitivity



Expensive Equipment
Limited scalability
Inhomogeneity



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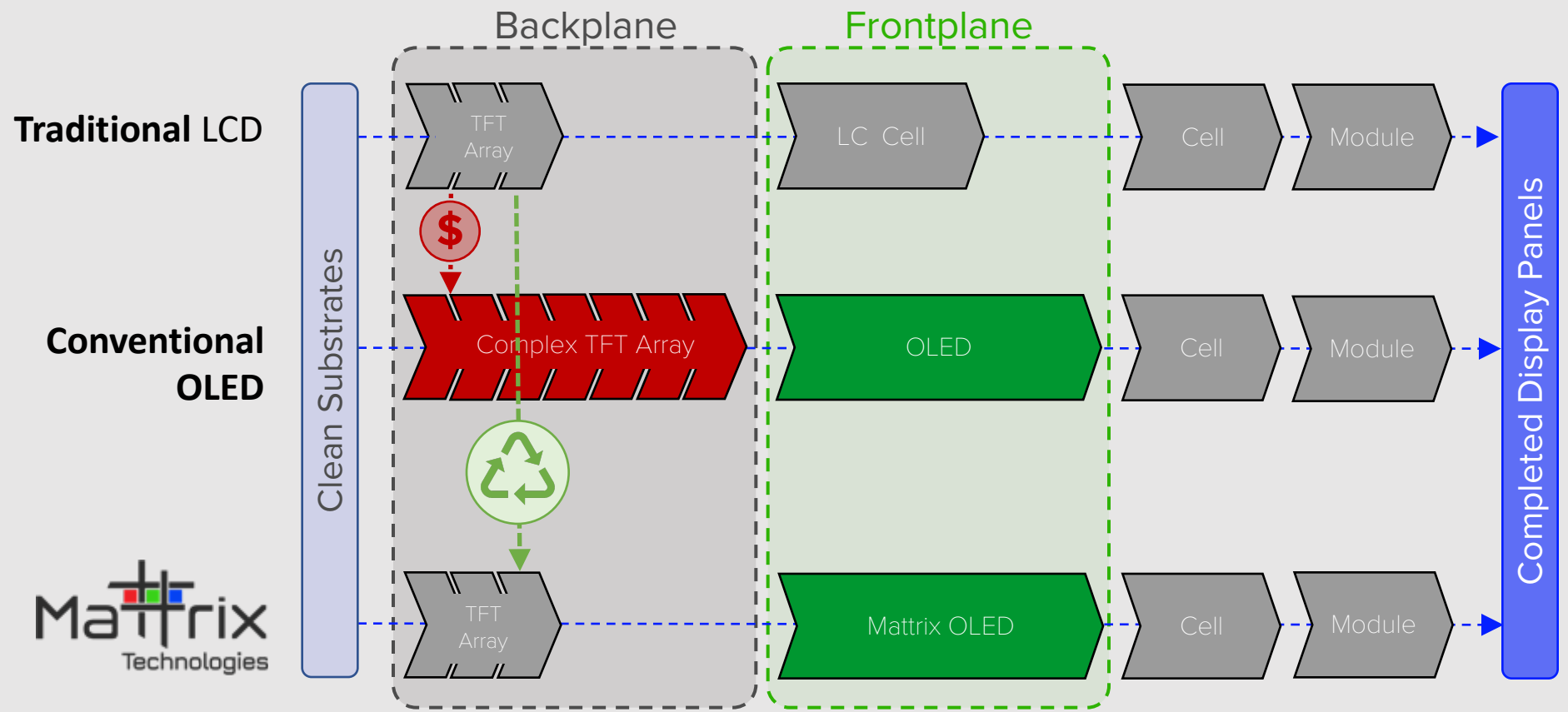
Mattrix's OLED Backplane SOLUTION

Mattrix circumvents what is known as the *"OLED backplane problem"*, allowing LCD TFT-array lines to be *recycled* for OLED manufacturing



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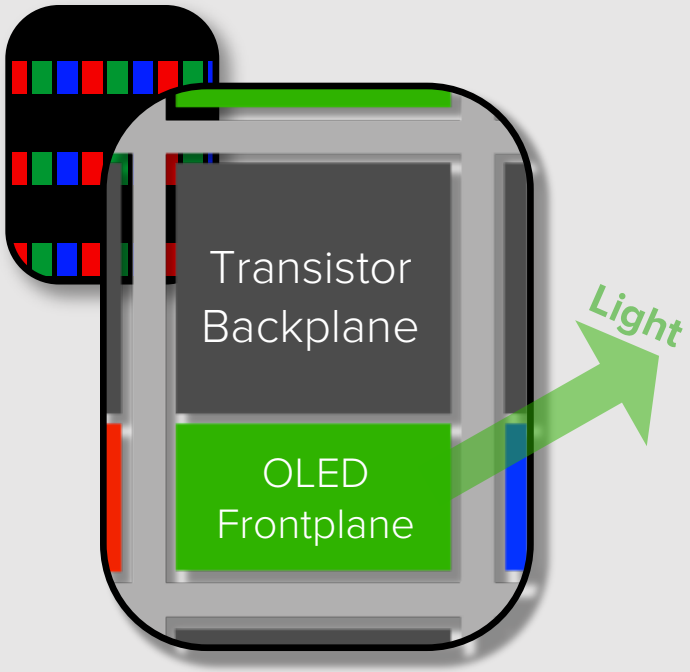
Mattrix's OLED Backplane SOLUTION

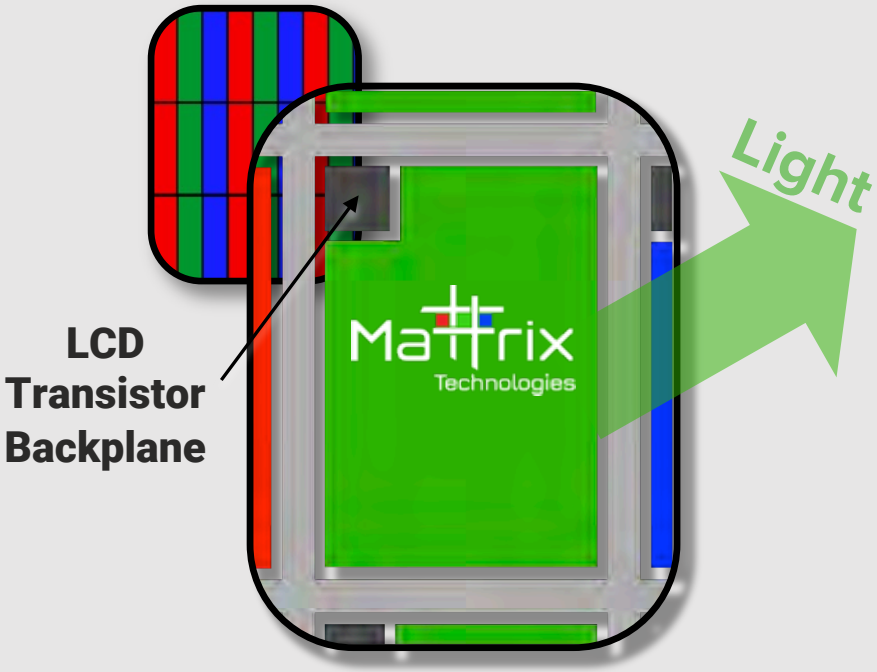
Conventional OLED Pixel

- Small light-emitting aperture
- Complex pixel circuit
- Difficult manufacturing process
- Challenging backplane materials



Simple Mattrix Pixel

- Large aperture ratio (>75%)
- Simple 2-component pixel design
- Mature LCD manufacturing process
- Compatible with large Gen sizes



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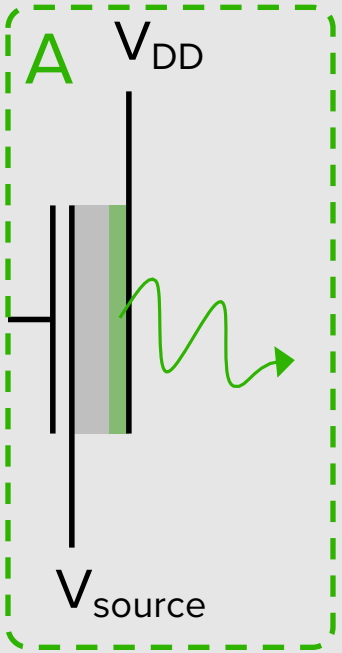
Mattrix's OLED Backplane SOLUTION

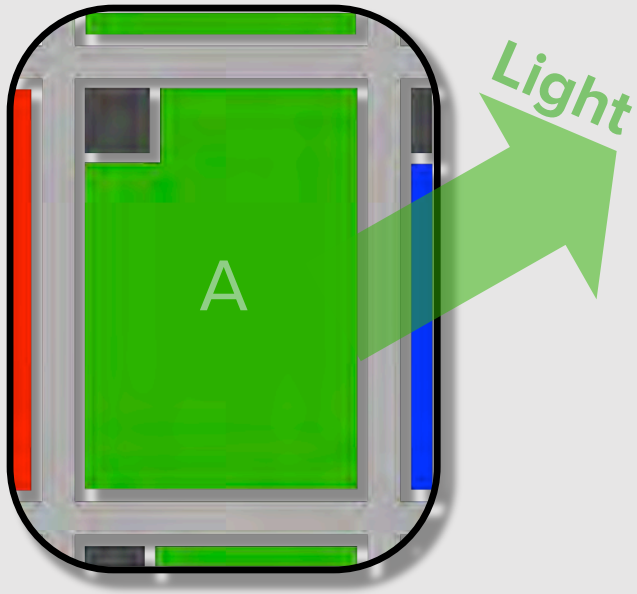
This simple pixel is enabled by our *patented* 3-in-1 device:

A. Vertical organic light emitting transistor (VOLET)

3-in-1 VOLET

- Drive transistor
- Storage capacitor
- Light-emitting stack





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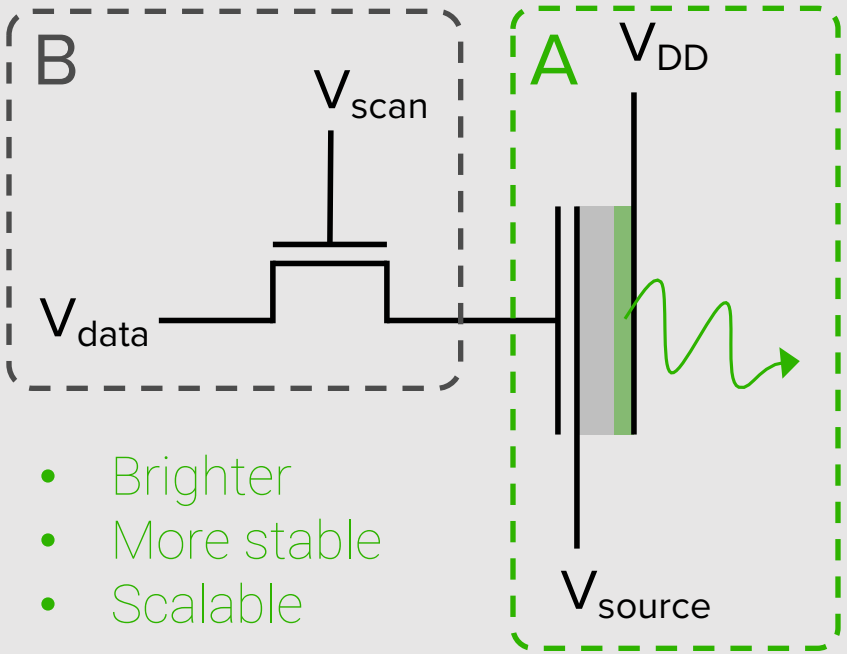
Mattrix's OLED Backplane SOLUTION

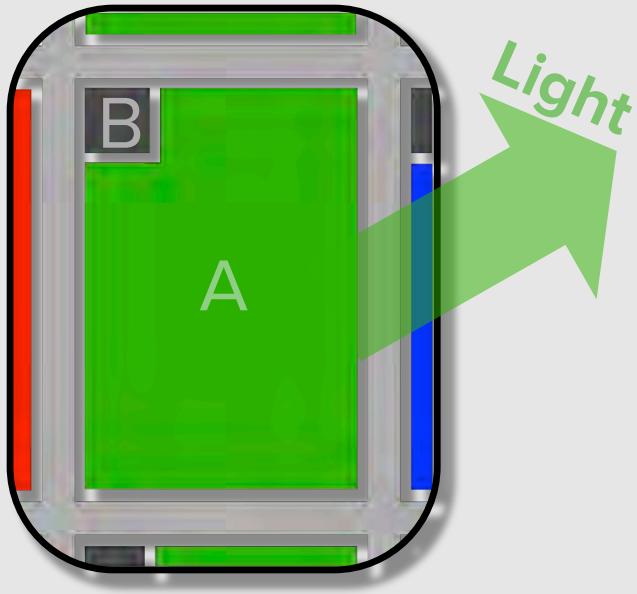
Now only TWO components per pixel (typically 4-9!)

A. Vertical organic light emitting transistor (VOLET)

B. Single LCD thin-film transistor



- Brighter
- More stable
- Scalable



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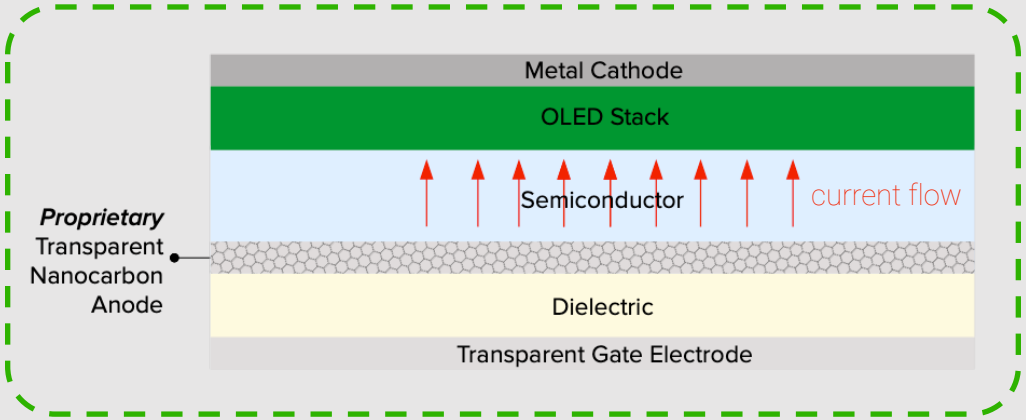
The Mattrix *VOLET*

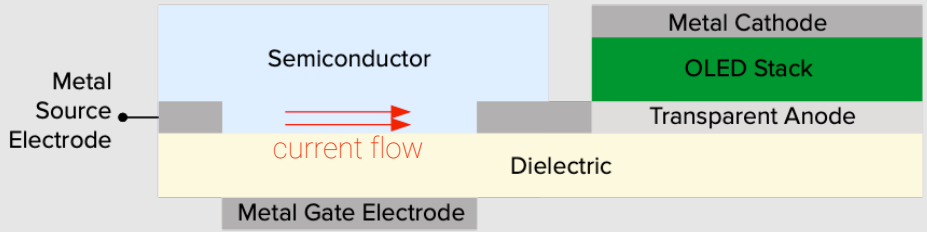
Mattrix Vertical organic light emitting *transistor* - A 3-in-1 optoelectronic device that combines the drive TFT, OLED, and storage capacitor into a single vertical device.



M. A. McCarthy, B. Liu *et. al.* and A. G. Rinzler, *Science*, 332, p. 570 (2011)

Mattrix VOLE *T*

- Able to source large current
- Bias, Temp., Illum. stress stable
- Highly uniform over large areas
- Low-cost manufacturing
- Stackable with OLED



Conventional *Lateral* TFT + OLED

- Poor uniformity
- Unstable current flow
- Low-yield manufacturing
- Side-by-side with OLED

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Value Proposition

Lower CAPEX

Higher Yields

Lower Material Cost

Greener Manufacturing

Compatible w/ all Emissive Tech

Industry Benefits

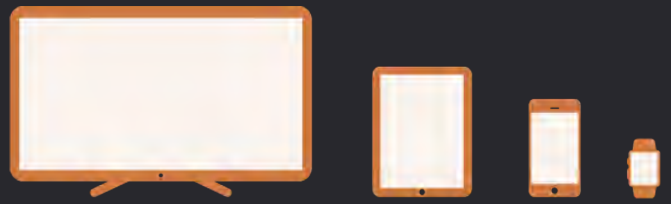
Reduced “image sticking”

Higher brightness

Fully transparent

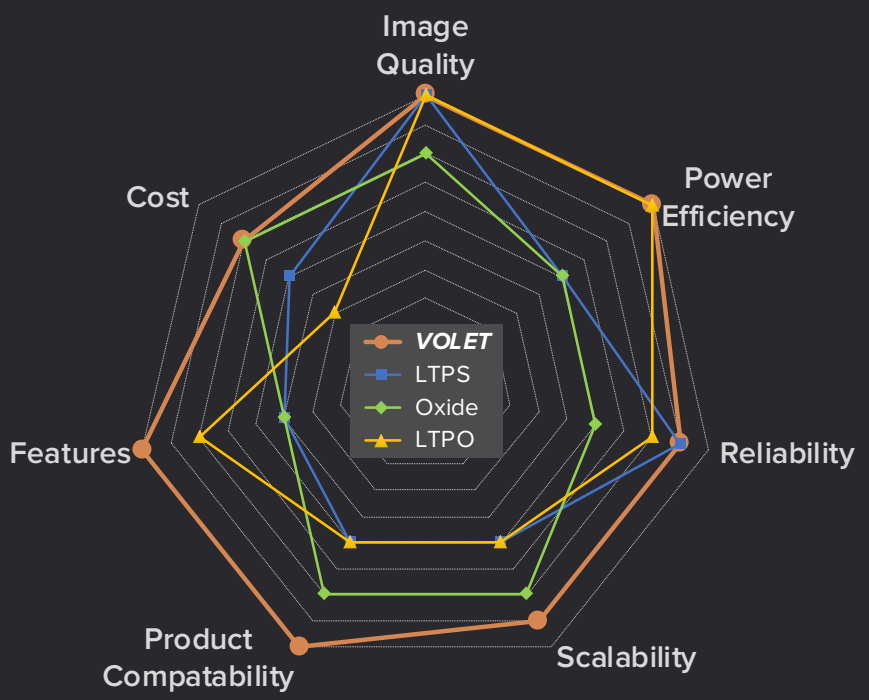
Longer lifetime

Truly bendable



User Features

Competitive Advantage



- Lowest cost backplane solution for OLED displays
- Matches performance of industry leading LTPO (Apple)
- Clear path for OLED at largest manufacturing Gen sizes (G10+)
- Enhances next-generation OLED or QD materials
- Compatible with ink-jet printing and roll-to-roll manufacturing

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Game Changing Possibilities

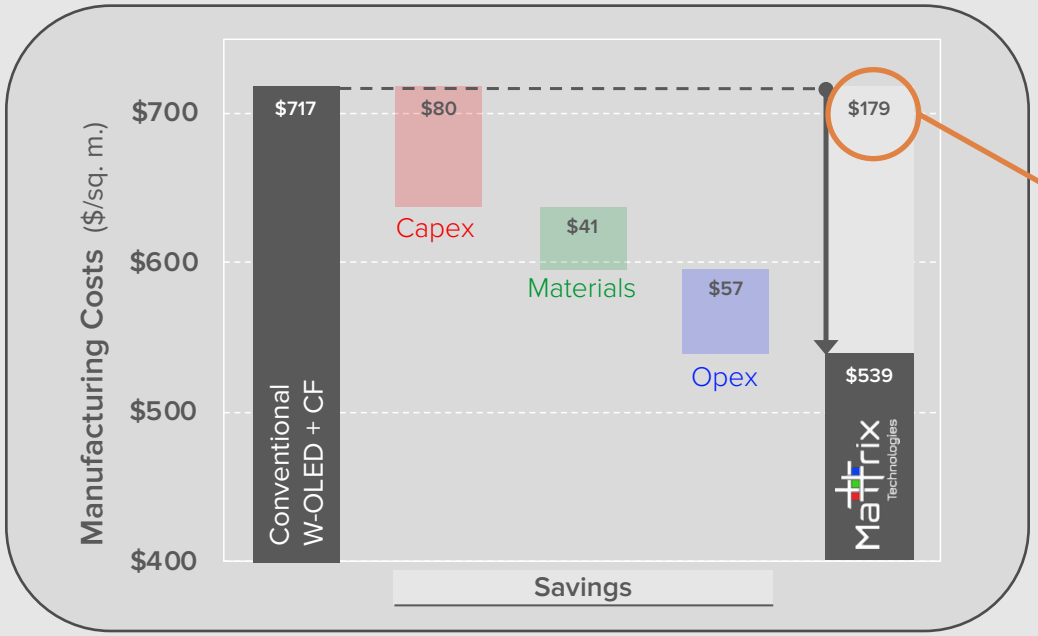
Low-cost OLED TV Displays

- No image burn-in
- 2x longer product lifetime
- Matches LCD peak brightness
- Fully transparent option

- 50% reduction in fab CAPEX
- Equivalent performance from lower-cost OLED materials
- Higher-yield a-Si TFT backplanes

Manufacturing Process

- Converted G8 LCD-TFT
- Bottom Emission
- White VOLET + Color Filter
- 1 a-Si sw-TFT backplane
- Glass Encapsulation



>25%

manufacturing cost savings per panel

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Game Changing Possibilities

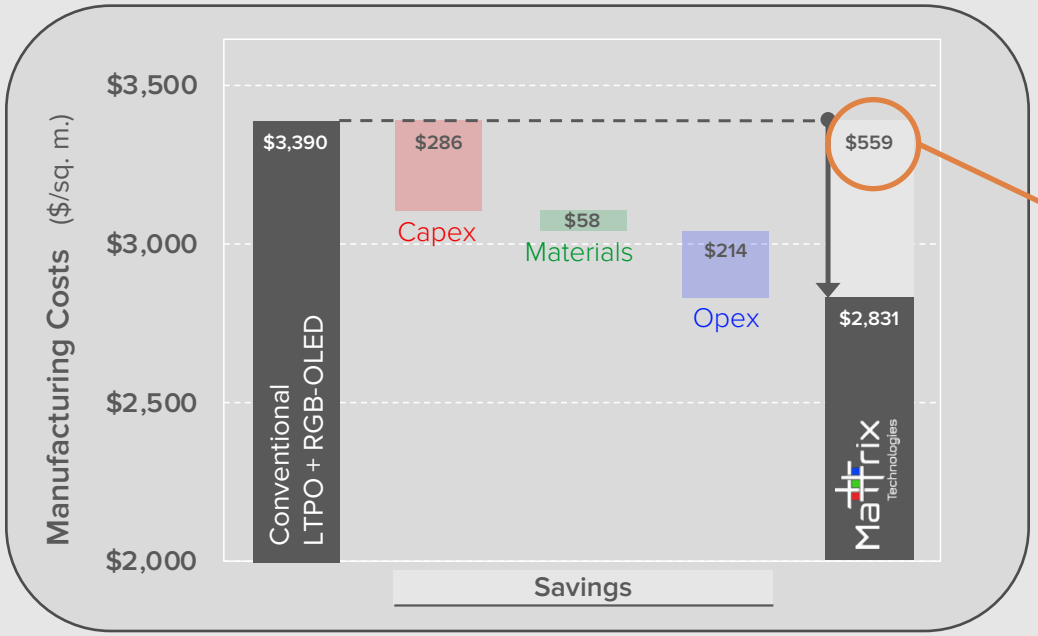
High-efficiency Smart Device:
Low-cost alternative to Apple's LTPO displays

- Always-on display (variable-refresh rate + low power consumption)
- Higher peak brightness
- Compatible with truly foldable/bendable form factors

- >30% less mask steps than LTPO process
- Scales to Gen 8+ (not limited by laser annealing step)
- Higher yields (eliminates deleterious hydrogen annealing step)

Manufacturing Process

- Converted G6/8 oxide-TFT
- Bottom Emission
- RGB-VOLET
- 1 oxide sw-TFT backplane
- Thin Film Encapsulation



>15%

manufacturing cost savings per panel

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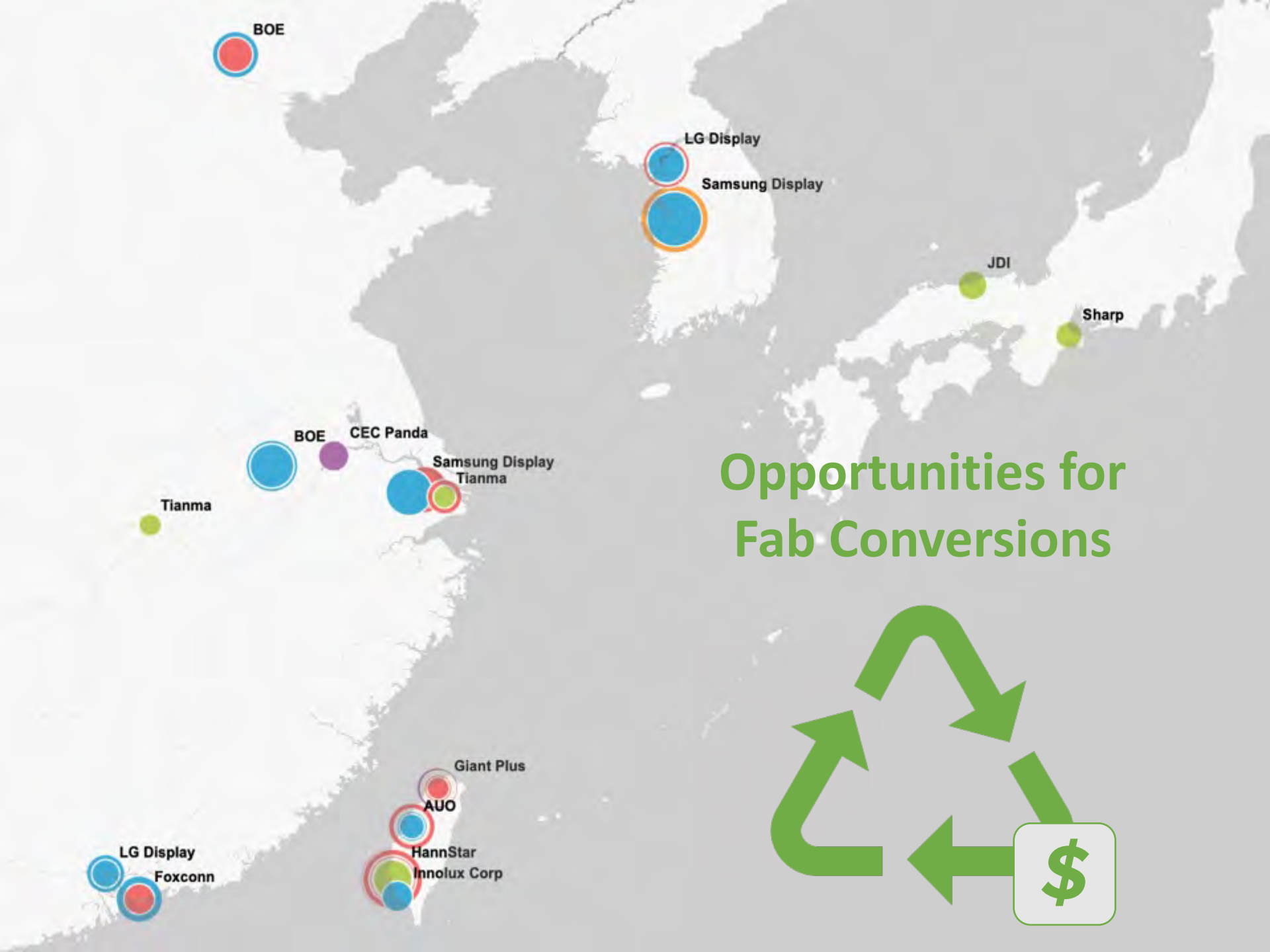
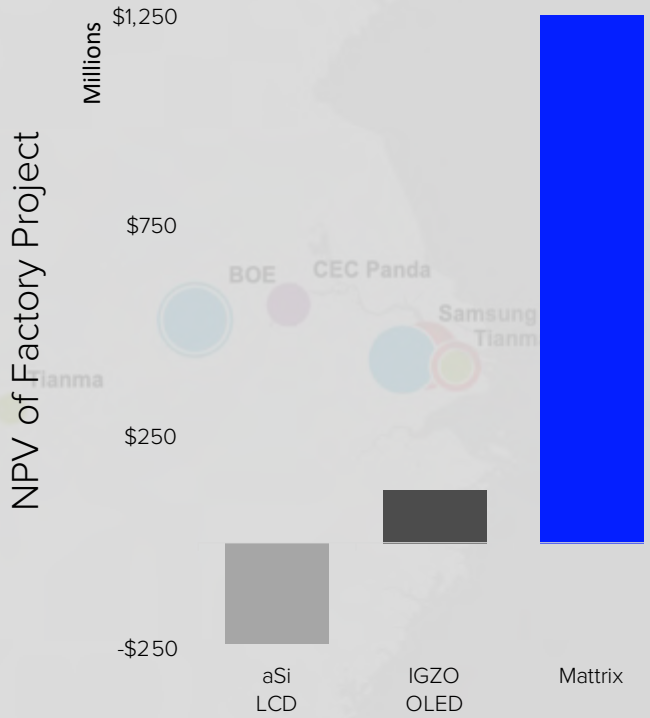
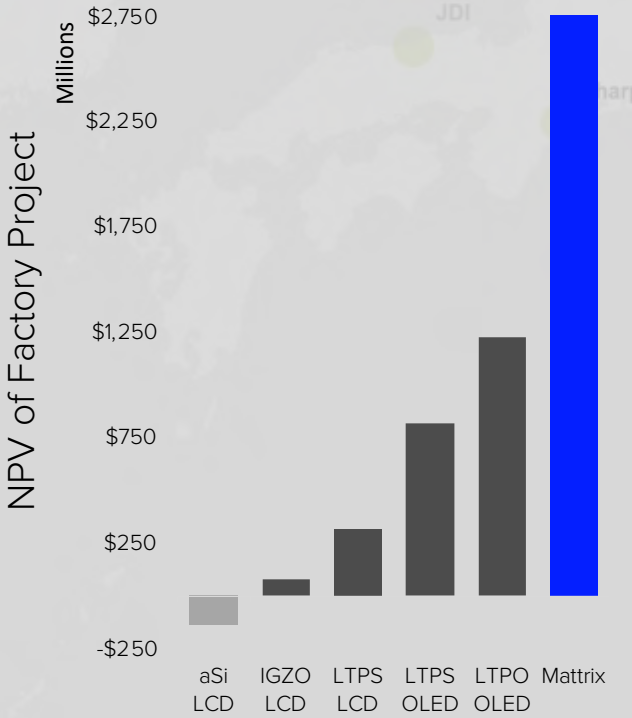

BOE
LG Display
Samsung Display
JDI
Sharp
BOE
CEC Panda
Samsung Display
Tianma
Tianma
Giant Plus
AUO
HannStar
Innolux Corp
LG Display
Foxconn
Opportunities for
Fab Conversions
$

Return on *Conversion*

DCF analysis of the value generated by converting a single aSi LCD line (30K sheets/mo)





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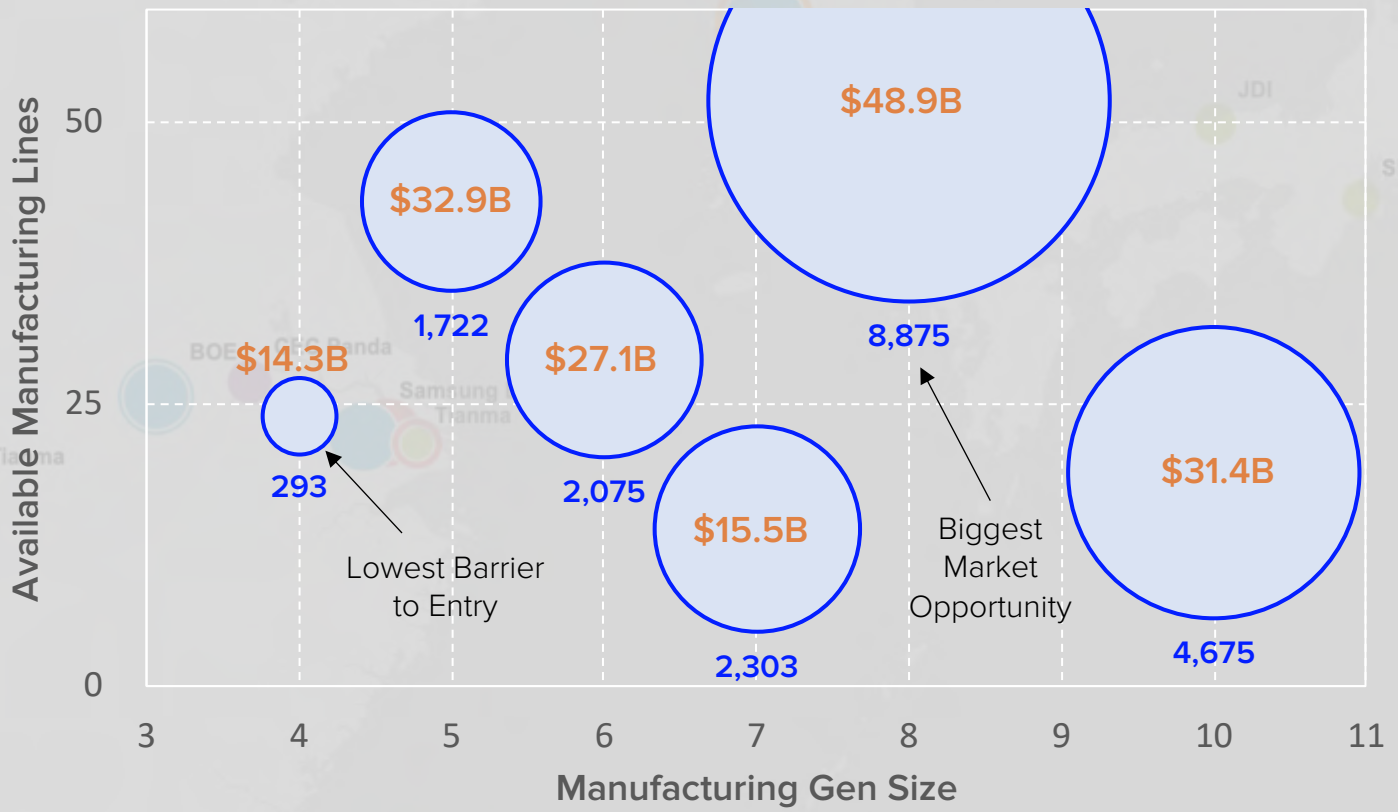
Addressable Market

Worldwide LCD Capacity Available for Mattrix Conversion



Total value of LCD-to-OLED conversions at each Gen size

Total LCD capacity available for conversion (1000's sq.m./mo)

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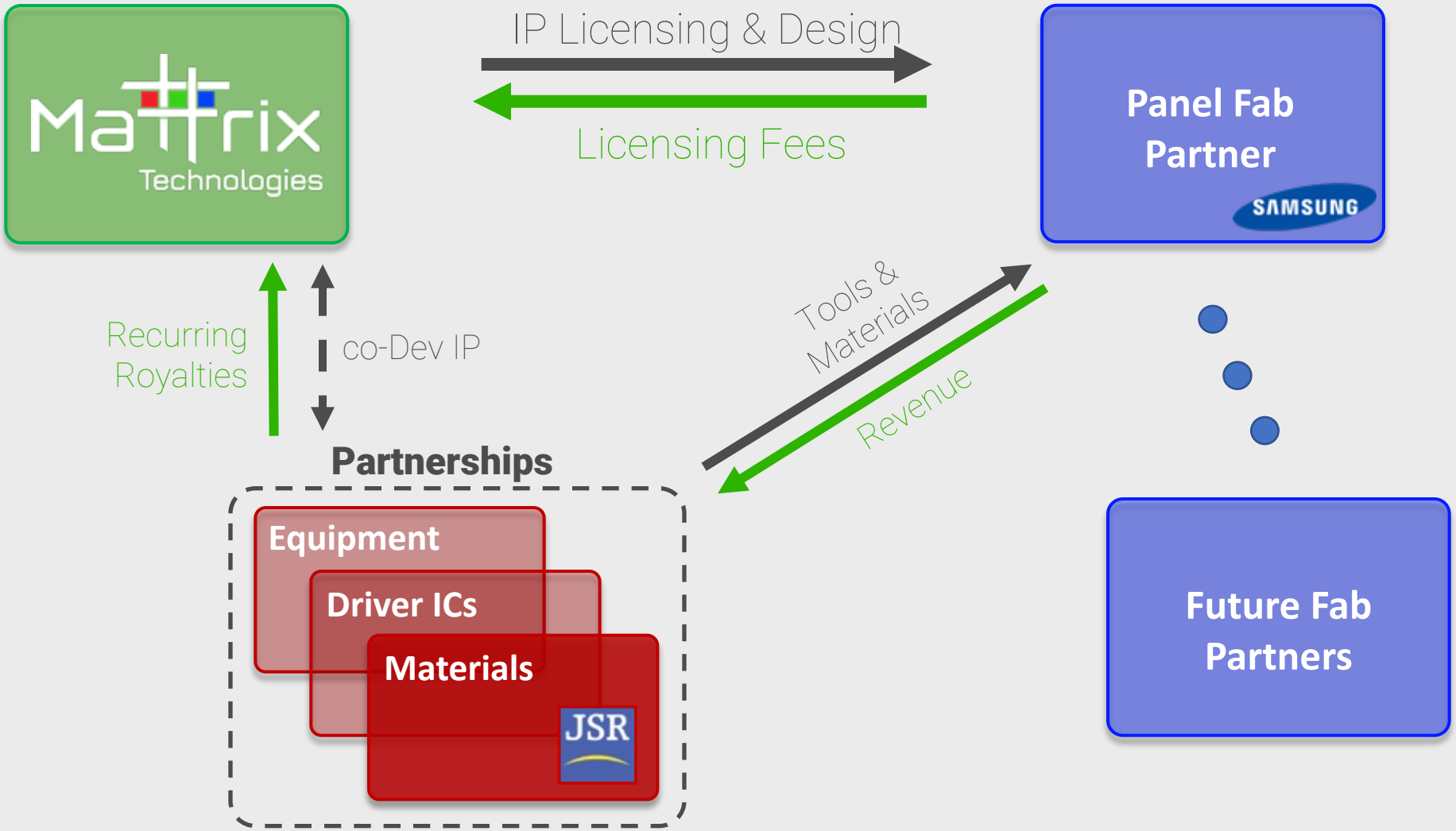
Mattrix Business Model



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Matrix Technologies

Spun-off in 2018
3 Founders
Now 20 Employees
14 PhDs

Max Lemaitre
Founder, CEO

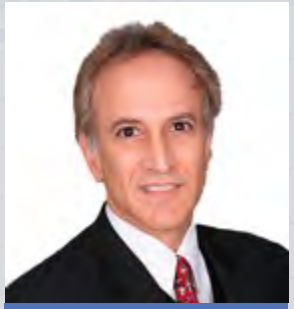
3rd Start-up
10 yrs in Hard Tech

Bo Liu
Founder, CTO

Inventor
15 yrs in Displays

Dr. Andrew Rinzler
Chief Scientific Advisor

Top 10 Most Cited
Nanotech Researcher



Bruce Berkoff
Industry Advisor

Ex-LGD, Ex-Philips
30+ yrs in Displays

Dr. Jin Jang
Scientific Advisor

SID Fellow, LG BOD
Top Display Scientist

DELTA DETECTION
PRINCETON UNIVERSITY
LCDTV
PHILIPS
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN
LG Display
nanosys
KYUNG HEE UNIVERSITY

Partnerships:

JSR
University of Florida 1853
SAMSUNG

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Traction

Industry Partnerships

- Investment lead by *Samsung Ventures*
- Backplane development with Silicon Display and the Advanced Display Research Center (KHU)
- Developing new *5" RGB VOLET prototype* with Samsung Advance Institute of Technology
- Novel materials *joint development* with JSR

Industry Validation

2013 Presented stable VOLET to SID
2014 Demonstrated high-uniformity at IMID
2016 Won SID *I-Zone Best Prototype Award*

Strong **IP portfolio** of 19 patents

- Architecture, materials, and process covered by *19 patents*
- *No "workaround"*

Scientific Validation

2004 Published dilute CNT films in *Science*
2006 Invented the CN-VFET
2010 Record performance from organic FET
2011 Published VOLET in *Science*

State-of-the-art **prototype** demonstrations (*TRL 5*):

- Record current efficiency
- Multi-color
- Bias and Illumination stress stability
- Pixel-to-Pixel Uniformity
- 2.5" QVGA video prototype

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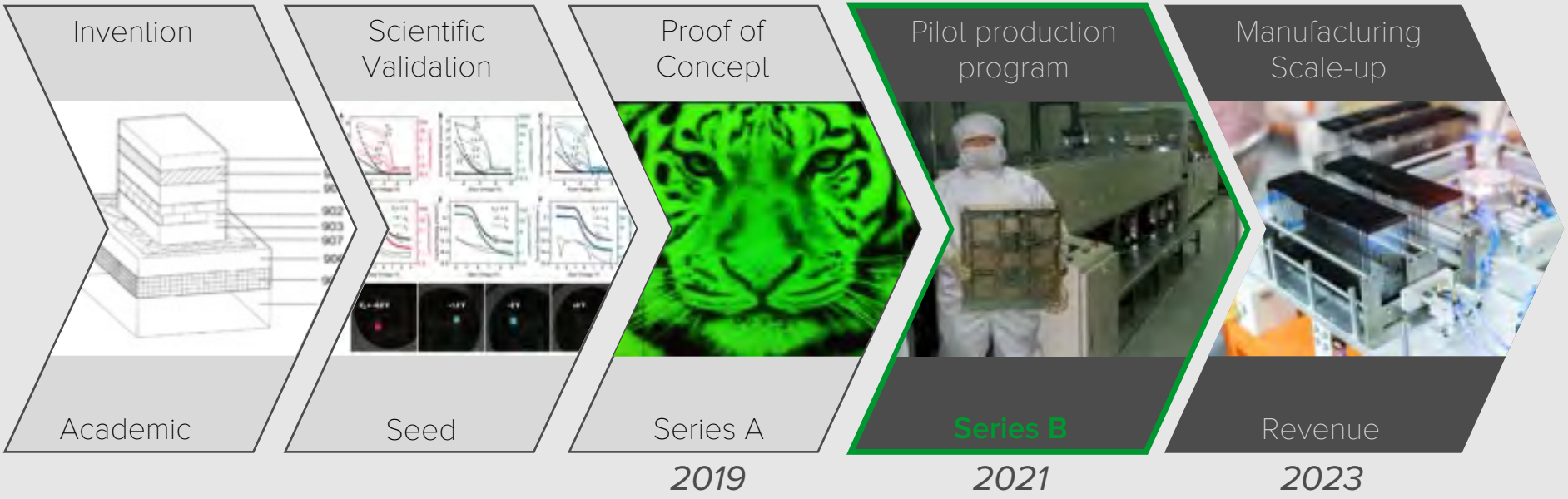
Commercialization Opportunity



Series B - Plugging into the display market

Investment Opportunity: *$10 - 15M*

- Build out business development operation (Korea, Japan, & China)
- Develop Gen 2.5 pilot line-ready CNT deposition tool,
- Complete pilot run of medium-size VOLET displays on contracted Gen 2.5 line,
- Design & optimize mass production grade materials set,
- Integrate pilot display with product-grade drive circuitry

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